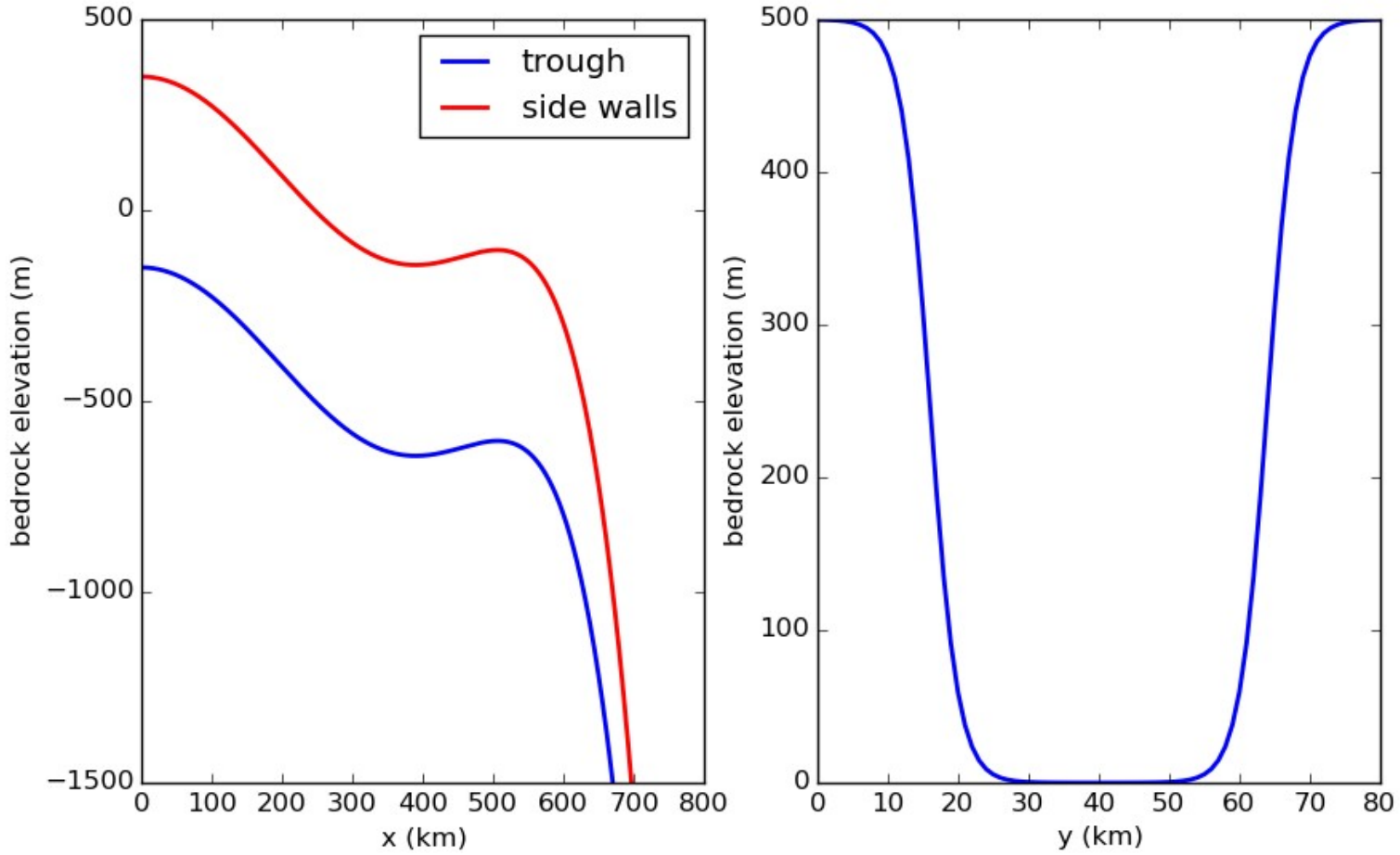
MISMIP+: Marine Ice Sheet
ISOMIP+: Ice Shelf-Ocean
MISOMIP: Marine Ice Sheet-Ocean Model Intercomparison Projects

“Rising Coastal Seas on a Warming Earth”

- November 2014
- Organized by David and Denise Holland
- Supported by the WCRP Climate and Cryosphere (CliC) and NYU Abu Dhabi
- Intercomparisons from idealized to realistic
- Community effort toward understanding climate change in West Antarctica
- 5 year time horizon
- Coordinate with MISMIP and ISMIP6

MISMIP+

- Third Marine Ice Sheet Model Intercomparison Project
- Bedrock topog. based on Gudmundsson et al. (2012)



MISMIP+

The Experiment:

- Begins at steady state with no melting
- 100 years of retreat w/ strong, depth-dependent melting based on Galton-Fenzi (personal comm.)

$$m = \frac{\rho_w c_w}{\rho_i L} \gamma_T \Omega (T_f - T)$$

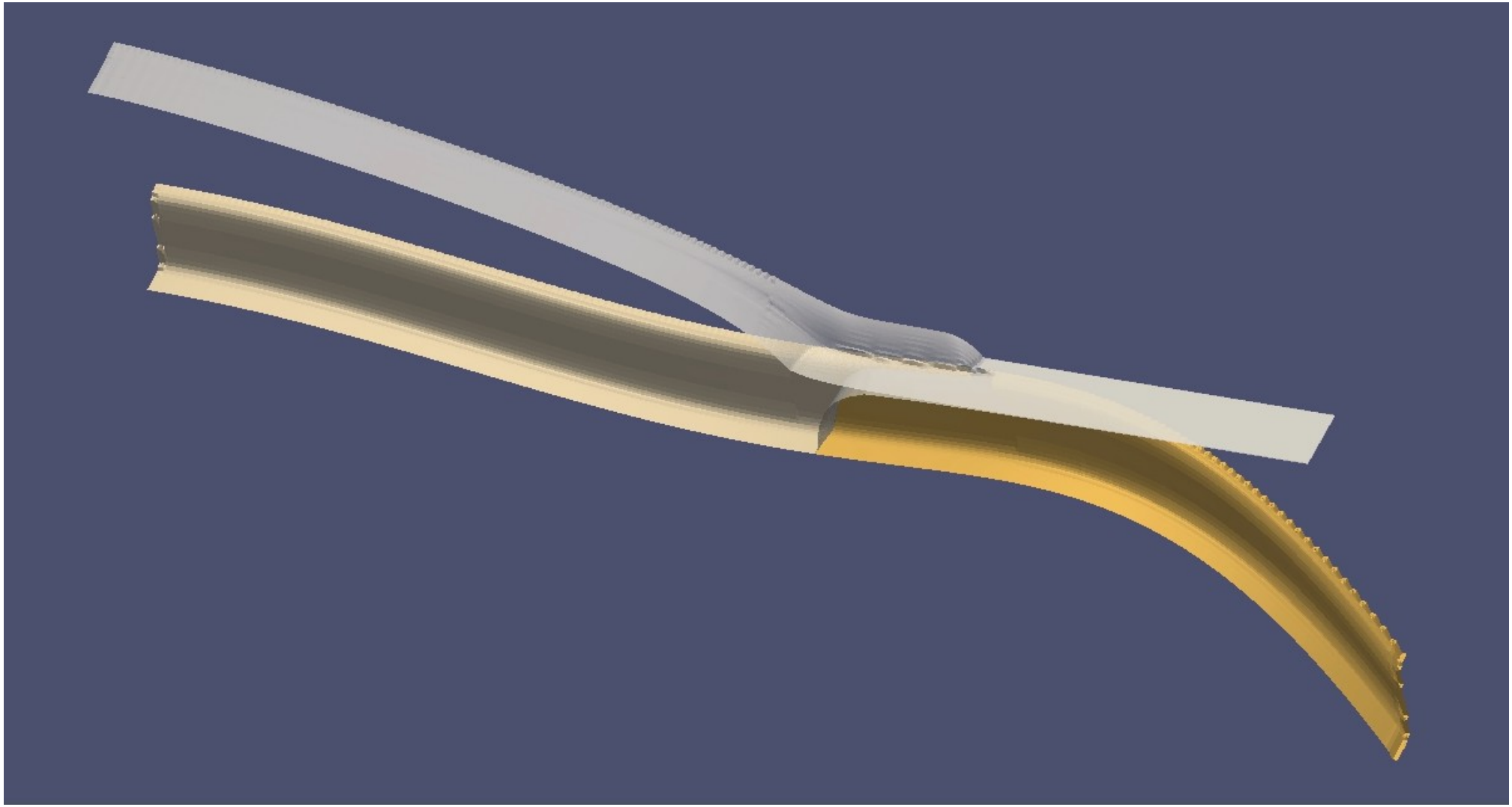
$$\Omega = 0.8 \frac{z_{\text{bot}}}{500} \tanh\left(e \frac{z_{\text{bot}} - z_{\text{base}}}{200} \right),$$

$$T = 2,$$

$$T_f = 7.61 \times 10^{-4} z_{\text{bot}} - 1.85.$$

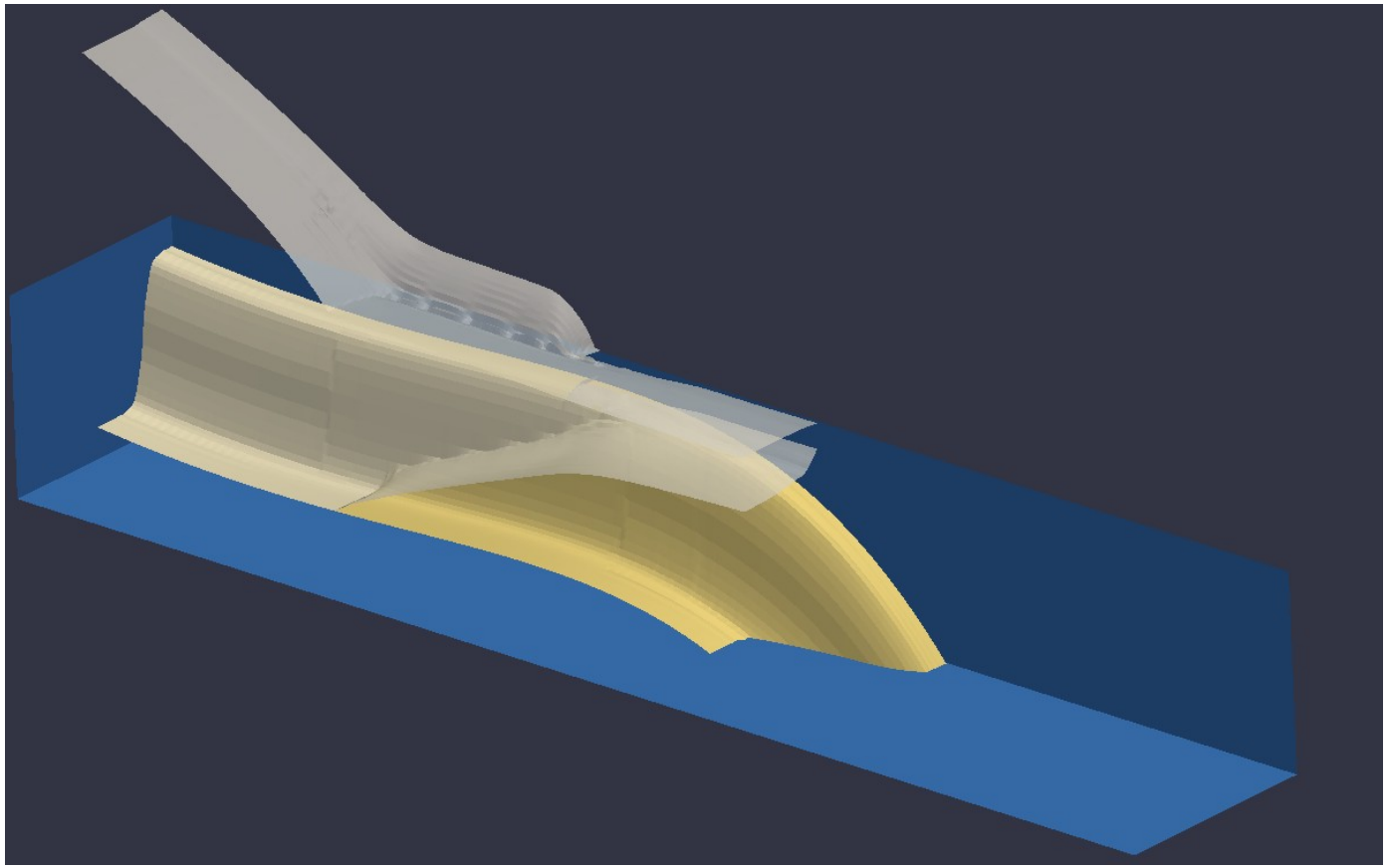
- 100 years of re-advance without melting

MISMIP+ retreat



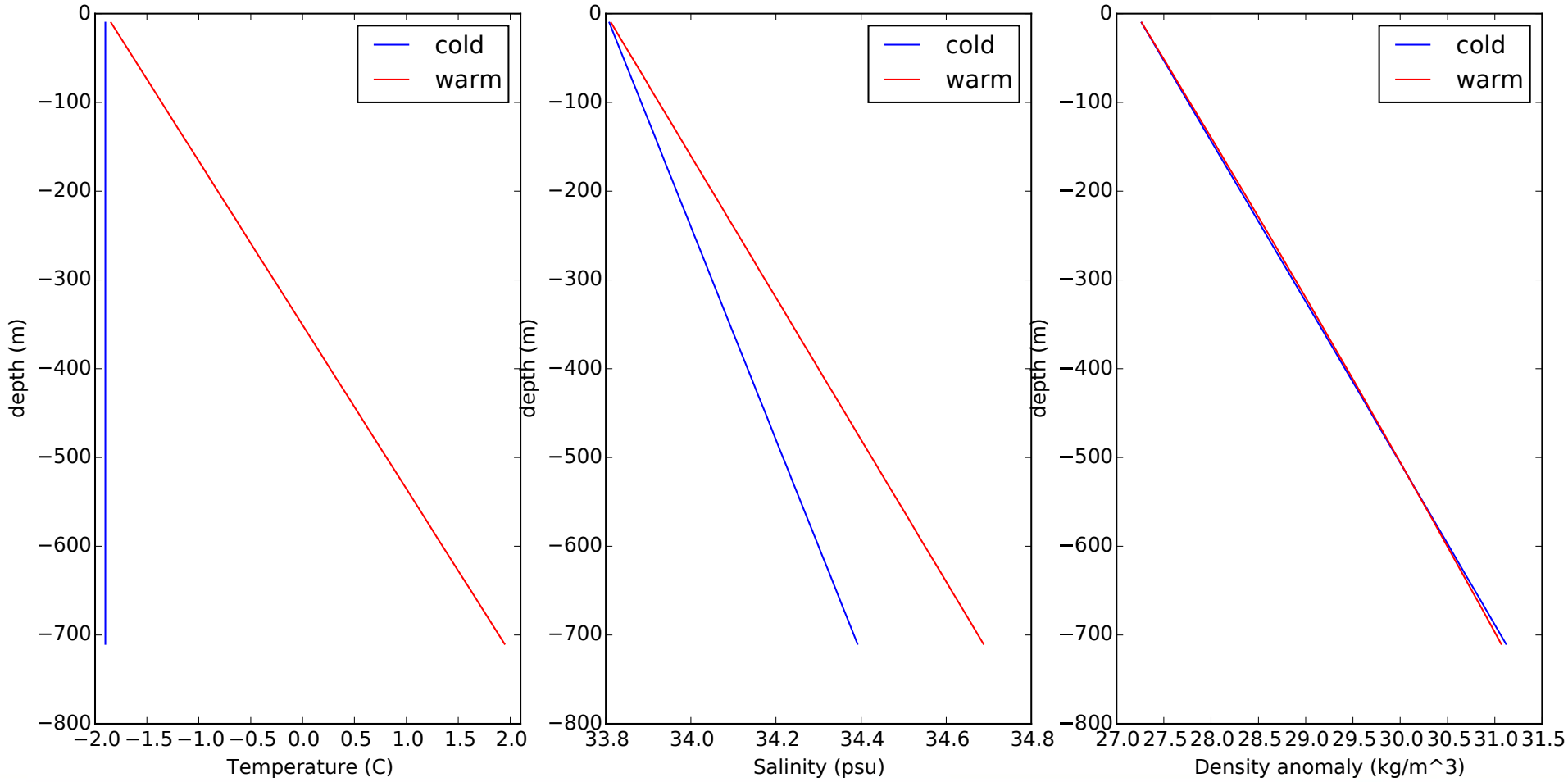
ISOMIP+

- Second Ice-Shelf Ocean Model Intercomparison Project
- Uses MISMIP+ topography (from BISICLES-SSA)
- Calving: ice under 100 m thick calves



ISOMIP+

- No sea-ice or atmospheric forcing
- COLD or WARM forcing: far-field restoring of temperature and salinity (as in Goldberg et al. 2012)

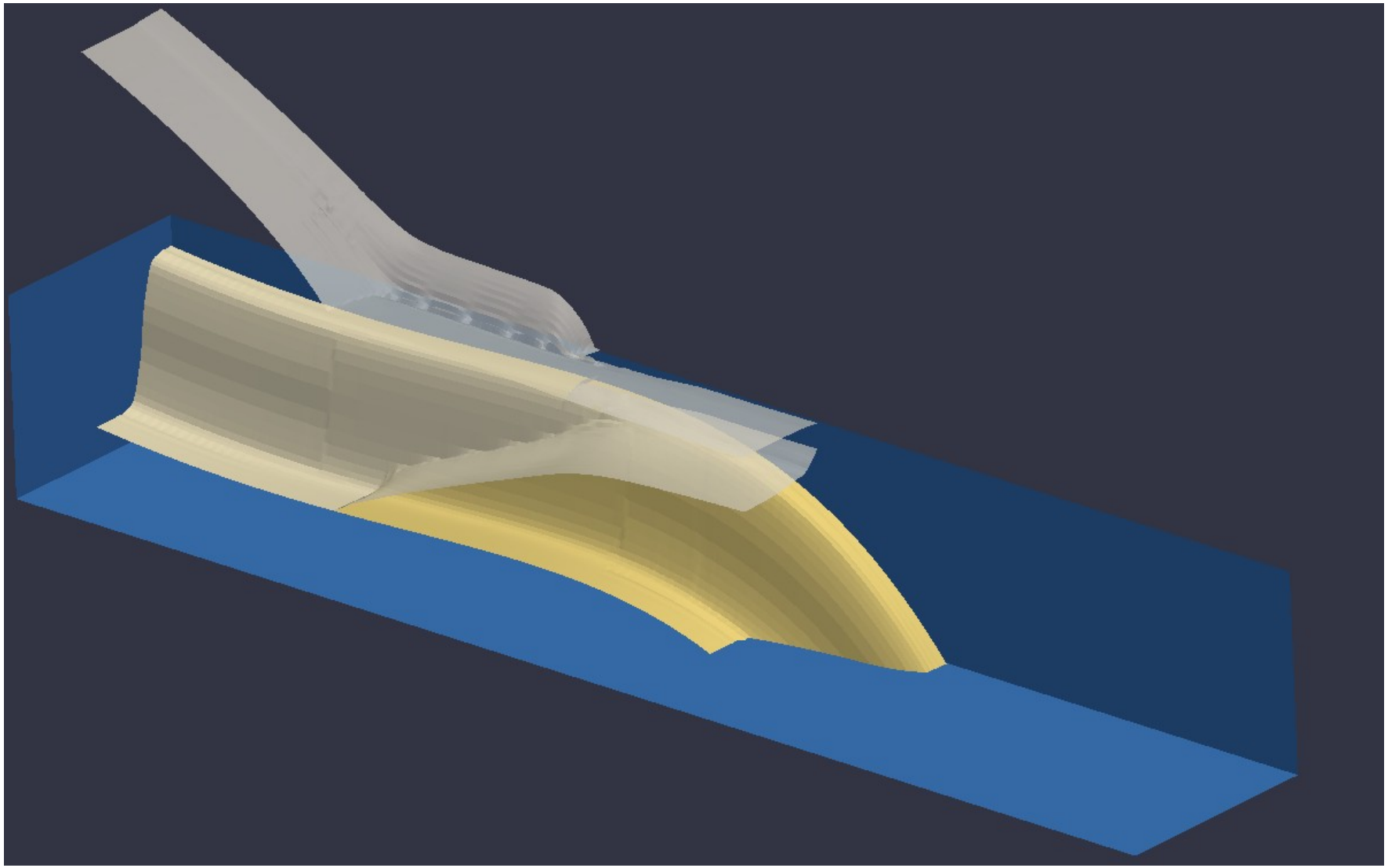


ISOMIP+ Configurations

- “Typical” (TYP) configuration:
  - Ask participants to use grid resolution and parameters of a “typical” run they perform
  - Results should show spread more typical of realistic model comparisons (e.g. CMIP)
- “Standard” (STD) configuration:
  - 2 km horizontal grid;
  - 20 m vertical resolution (depending on vertical coord.)
  - Parameterizations specified (horiz., vert. diffusion; melt boundary conditions, etc.)

ISOMIP+

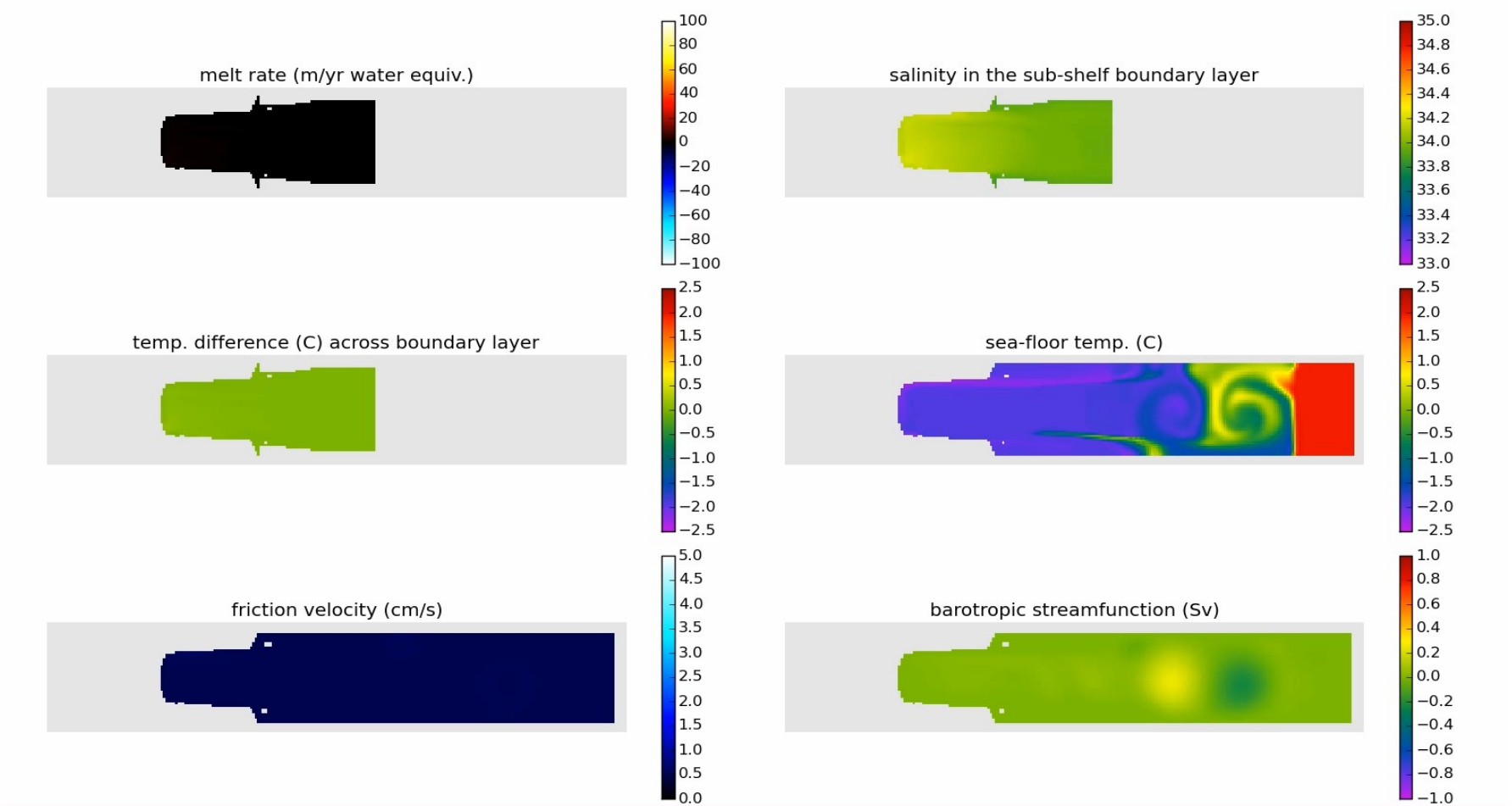
Experiment 1 geometry



The Four ISOMIP+ Experiments

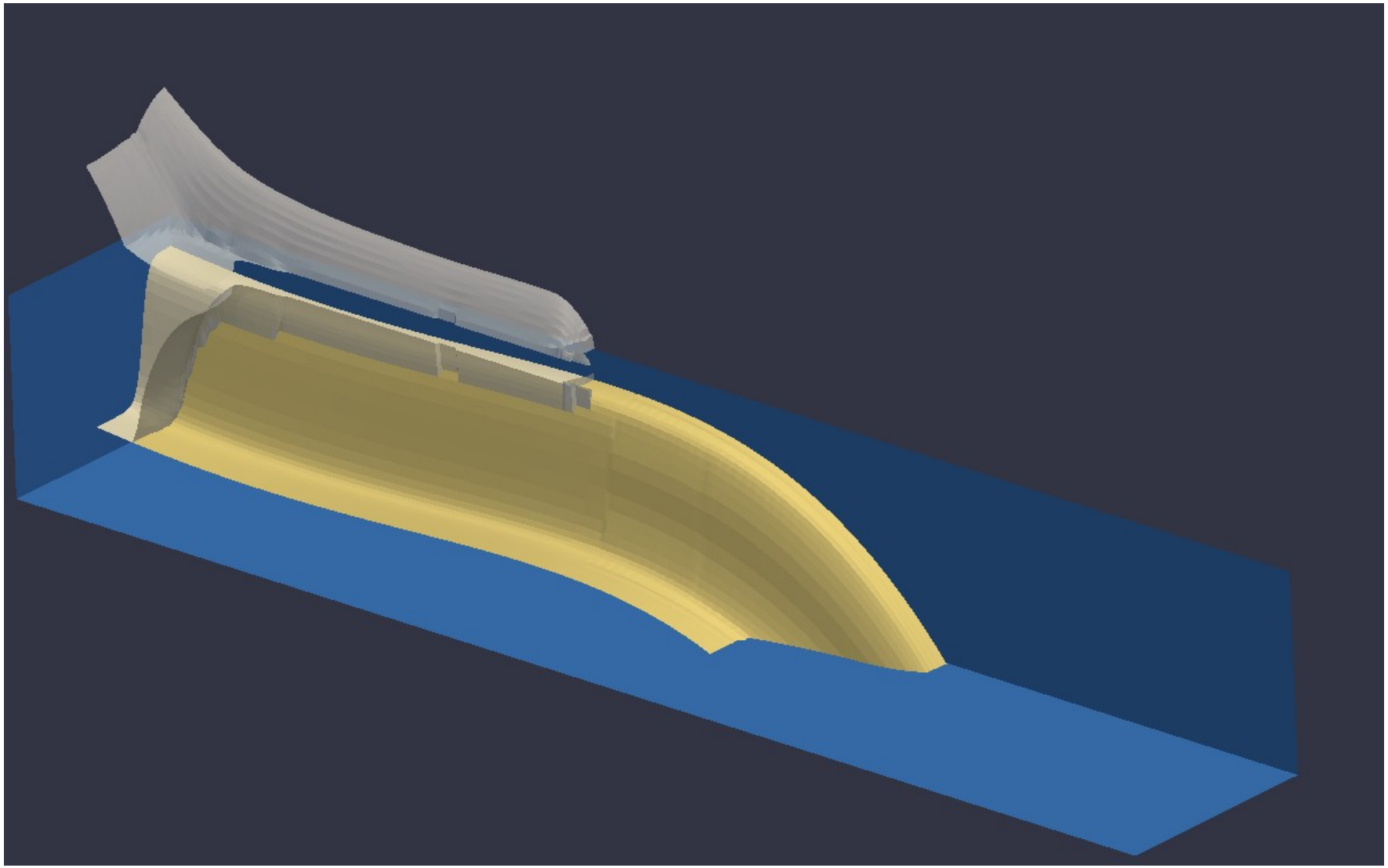
Two experiments with fixed ice-shelf geometry

- Expt 1: advanced geom; cold i.c.; warm forcing



ISOMIP+

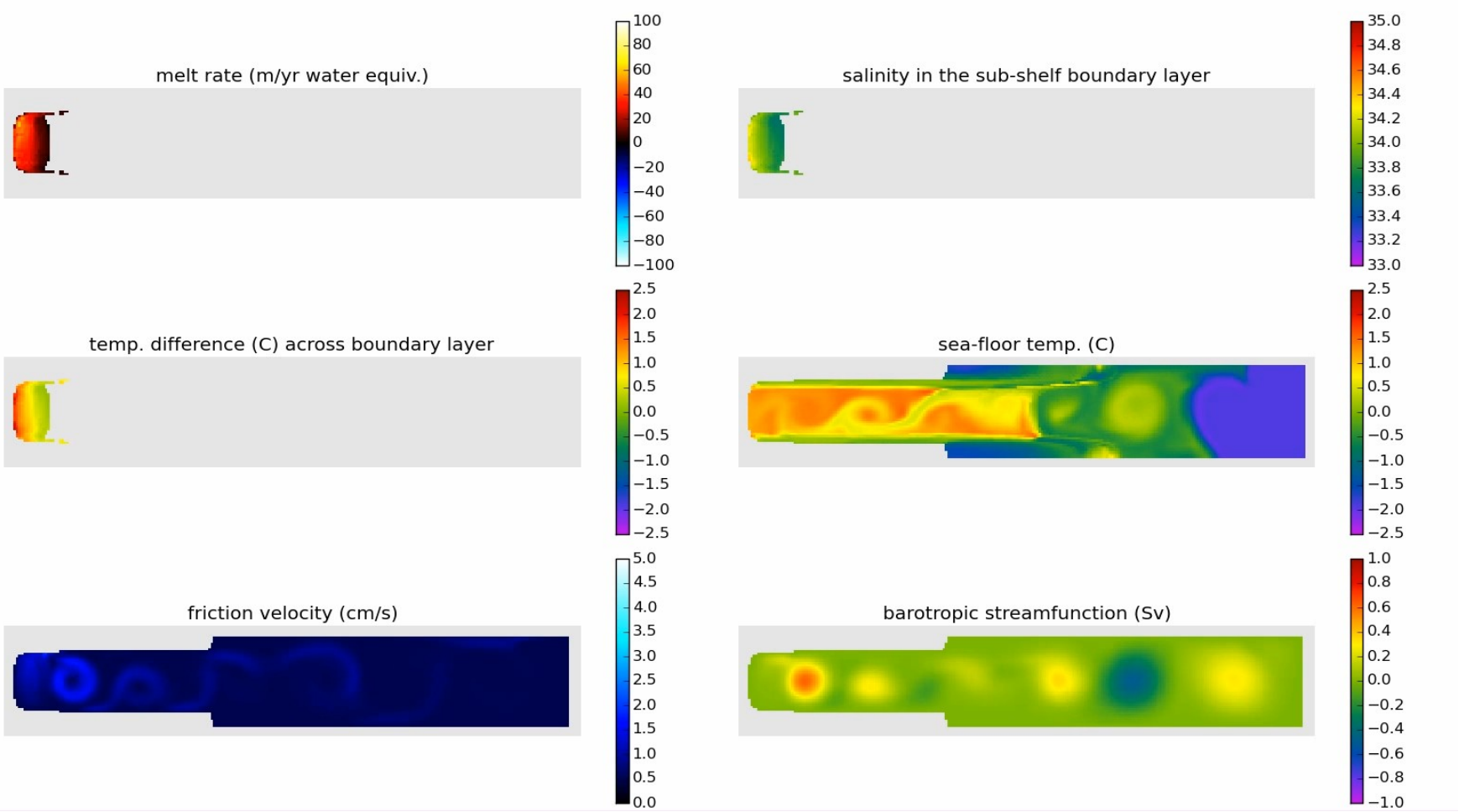
Experiment 2 geometry



The Four ISOMIP+ Experiments

Two experiments with fixed ice-shelf geometry

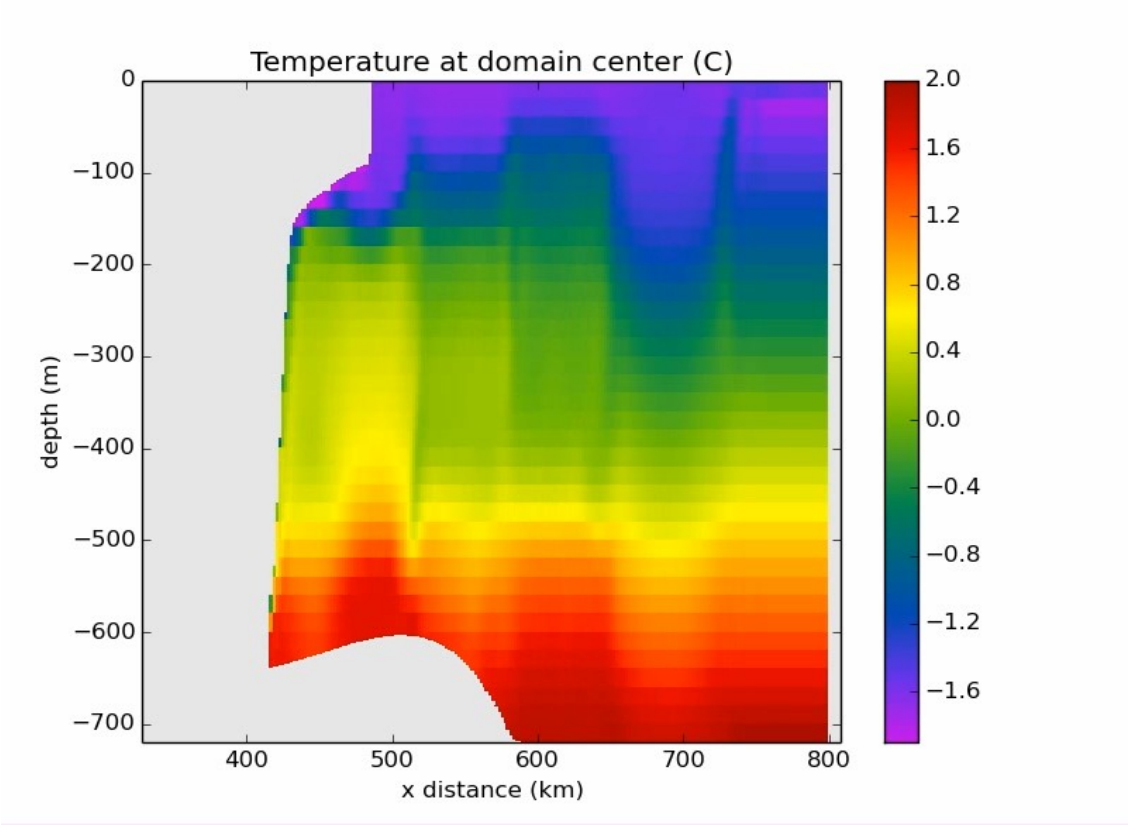
- Expt 2: retreated geom; warm i.c.; cold forcing



The Four ISOMIP+ Experiments

Two experiments with prescribed dynamic geometry

- Expt 3: retreating geom; warm i.c. and forcing
- Expt 4: re-advancing geom; cold i.c. and forcing

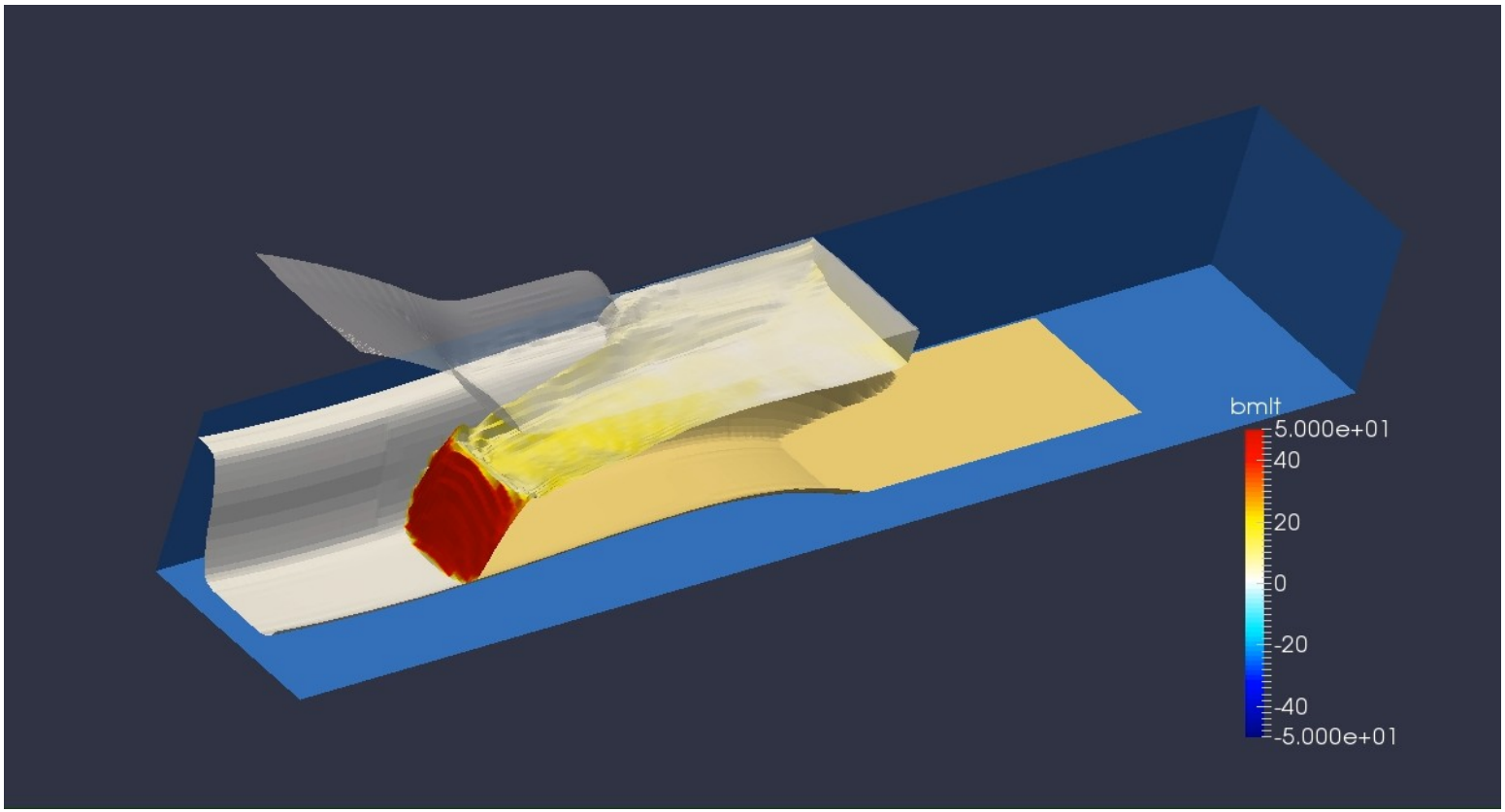


ISOMIP+: parameter studies

- Intended as reference experiments from which parameter studies can be performed
- Examples:
  - Tides
  - Atmospheric and/or Sea-ice Forcing
  - Modified bed topography
  - Modified mixing parameters/parameterizations
  - Modified melt parameterizations
  - Alternative model resolutions
  - Alternative calving law

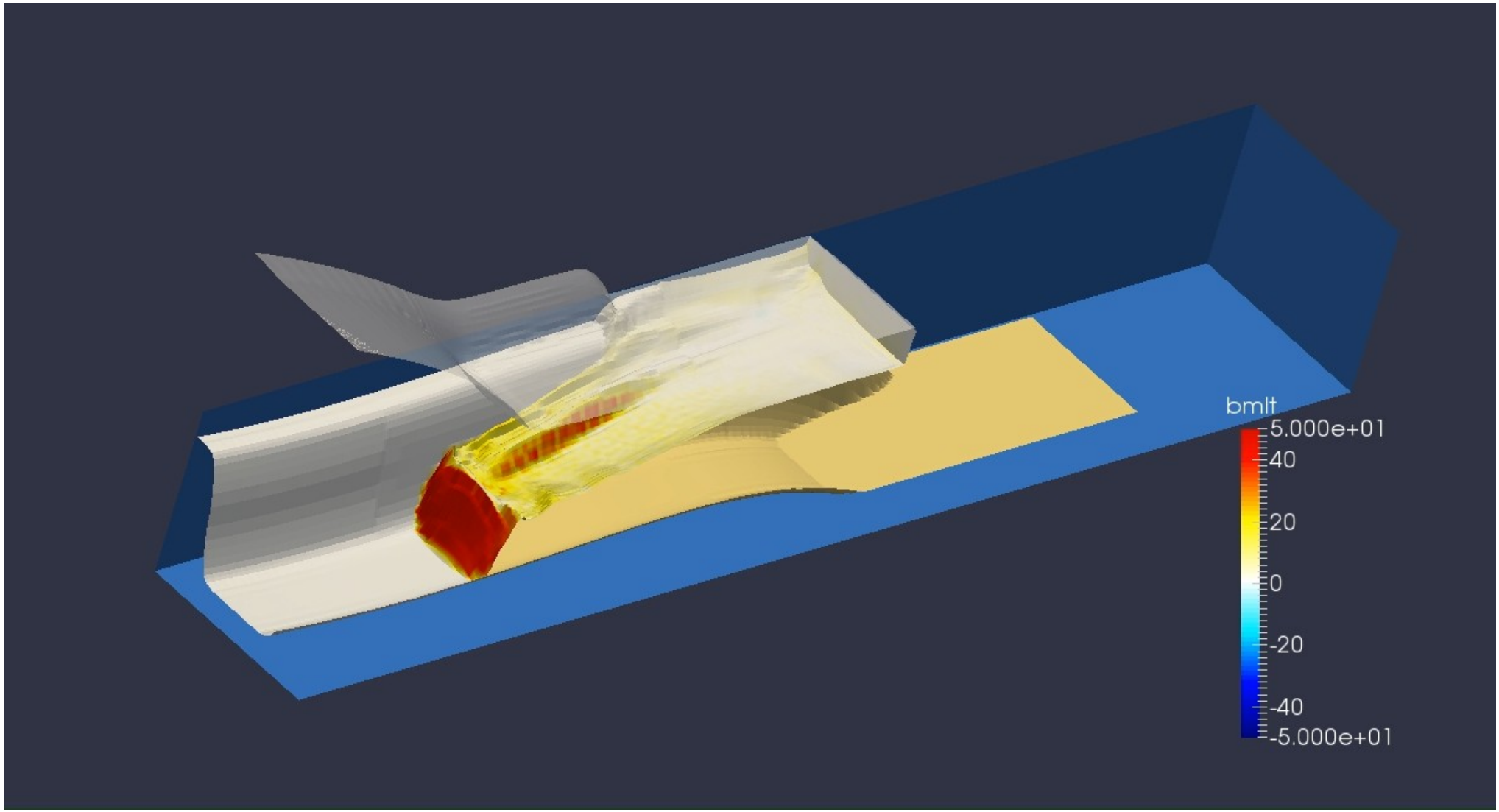
MISOMIP

- Essentially MISMIP+ coupled to ISOMIP+
- 100 years of retreat driven by WARM ocean forcing (in progress)
- 100 years of re-advance with COLD ocean forcing (not yet tested)



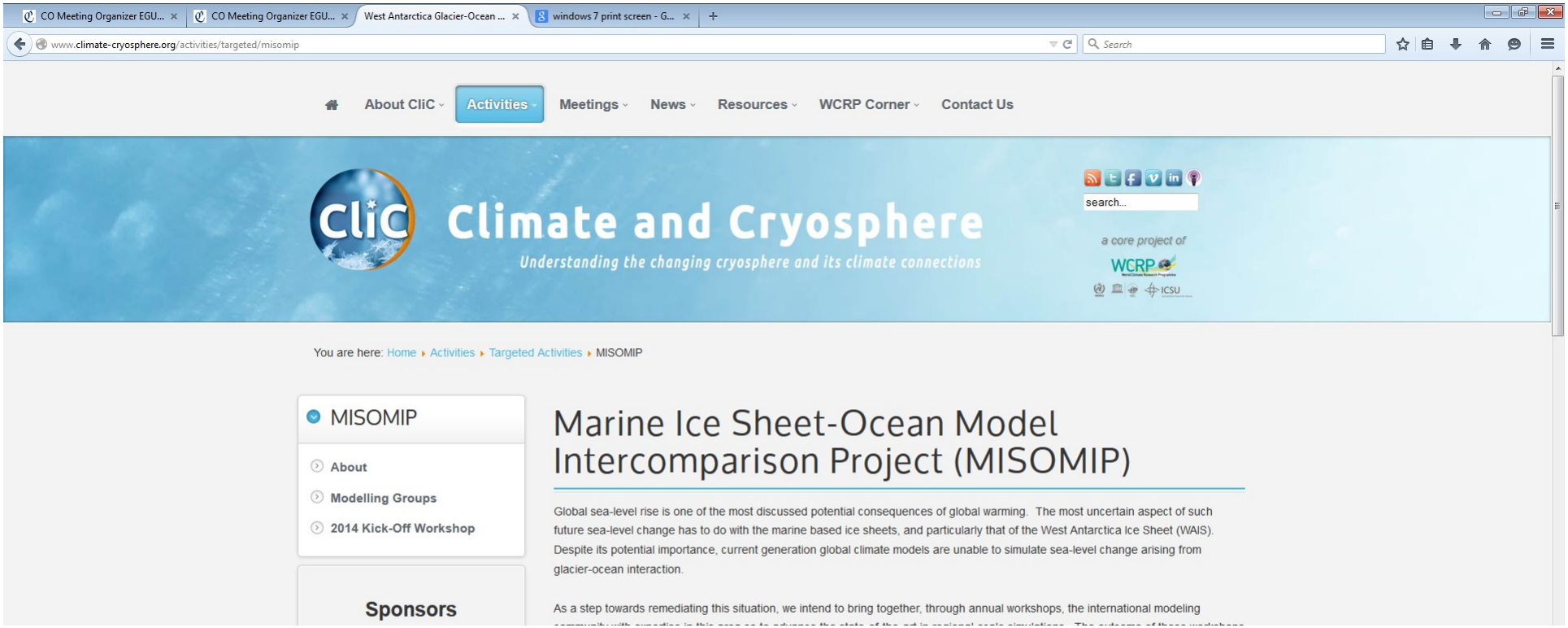
MISOMIP

- Melt channel appears at higher ocean vertical resolution (10 m)



MISOMIP Website and Email List

- http://www.climate-cryosphere.org/activities/targeted/misomip



- Example input data and results: http://portal.nersc.gov/project/iceocean/
- To join the MISOMIP Google Group, send me a request: xylar.asay-davis@pik-potsdam.de

Topography and Parametizations

$$
\begin{aligned}
B(x,y) &= \max\left(B_x(x) + B_y(y), B_{max}\right), \\
B_x(x) &= B_0 + B_2\tilde{x}^2 + B_4\tilde{x}^4 + B_6\tilde{x}^6, \\
\tilde{x} &= x/\bar{x} \\
B_y(y) &= \frac{d_c}{1 + e^{-2(y - L_y/2 - w_c)/f_c}} + \frac{dc}{1 + e^{2(y - Ly/2 + w_c)/f_c}},
\end{aligned}
$$

$$
\begin{aligned}
m_w L &= -c_p u_* \Gamma_T \left(T_f - T_w\right), \\
u_*^2 &= C_{D,top} u_w^2, \\
T_f &= \lambda_1 S_b + \lambda_2 + \lambda_3 p_b, \\
m_w S_b &= -u_* \Gamma_S \left(S_b - S_w\right),
\end{aligned}
$$

$$
\frac{\partial T}{\partial t} = \cdots - \frac{T - T_{\text{restore}}}{\tau},
$$

Fluxes

- Virtual Salt Fluxes

$$
\begin{aligned}
F_{fw} &= 0 \\
F_H &= -c_p \left(u_* \Gamma_T + m_w\right)\left(T_f - T_w\right), \\
F_S &= -\left(u_* \Gamma_S + m_w\right)\left(S_b - S_w\right).
\end{aligned}
$$

- Volume fluxes

$$
\begin{aligned}
F_{fw} &= m_w \\
F_H &= -c_p \left[m_w T_f + u_* \Gamma_T \left(T_f - T_w\right)\right], \\
F_S &= 0.
\end{aligned}
$$

Parameters

Table 1. Parameters common to all three ISOMIP+ experiments

Parameter	Value	Description
L_x	400 km	Domain length (along ice flow)
L_y	80 km	Domain width (across ice flow)
B_{max}	-720 m	Maximum depth of the ocean
B_0	-150.0 m	Bathymetry at $x = 0$
B_2	-728.8 m	Second bathymetry coefficient
B_4	343.91 m	Third bathymetry coefficient
B_6	-50.57 m	Forth bathymetry coefficient
$\bar{x}$	300 km	Characteristic along-flow length scale of the bathymetry
f_c	4.0 km	Characteristic width of the side walls of the channel
d_c	500 m	The depth of the trough compared with the side walls
w_c	24 km	The half-width of the trough
H_{calve}	100 m	The minimum thickness of ice, below which it is removed
x_{calve}	600 km	The location in x, beyond which ice is removed
θ_c	75°S	Latitude of the center of the domain
L_{sponge}	50 km	Width of the sponge layer
τ_0	0.1 days	The time scale of restoring at the eastern edge of the sponge layer

Parameters

Table 2. Parameters recommended for the *standard* experiments

Parameter	Value	Description
$\Delta x = \Delta y$	2 km	Horizontal resolution
Δz	20 m	Approx. vertical resolution in the open ocean
c_p	3974 $\mathrm{J\,^\circ C^{-1}\,kg^{-1}}$	Specificheat capacity of seawater
L	3.34×10^5 $\mathrm{J\,kg^{-1}}$	Latent heat of fusion of ice
λ_1	$-0.0573^\circ\mathrm{C\,psu^{-1}}$	Liquidus slope
λ_2	$0.0832^\circ\mathrm{C}$	Liquidus intercept
λ_3	$-7.53 \times 10^{-8}{}^\circ\mathrm{C\,Pa^{-1}}$	Liquidus pressure coefficient
Γ_T	2.2×10^{-2}	Nondimensional heat-transfer coefficient
Γ_S	6.2×10^{-4}	Nondimensional salt-transfer coefficient
$C_{D,\mathrm{top}}$	2.5×10^{-3}	top drag coefficient
$C_{D,\mathrm{bot}}$	2.5×10^{-3}	bottom drag coefficient
κ_i	0	heat diffusivity into ice (perfectly insulating)
ν_{uns}	$0.1\ \mathrm{m^2\,s^{-1}}$	Convective vertical viscosity
κ_{uns}	$0.1\ \mathrm{m^2\,s^{-1}}$	Convective vertical diffusivity
ν_{bkg}	$1 \times 10^{-4}\ \mathrm{m^2\,s^{-1}}$	Background vertical viscosity
κ_{bkg}	$1 \times 10^{-5}\ \mathrm{m^2\,s^{-1}}$	Background vertical diffusivity
ν_0	$5 \times 10^{-3}\ \mathrm{m^2\,s^{-1}}$	Neutral vertical viscosity
ν_H	$-1.57 \times 10^8\ \mathrm{m^4\,s^{-1}}$	Biharmonic horizontal viscosity
κ_H	$-1.75 \times 10^7\ \mathrm{m^4\,s^{-1}}$	Biharmonic horizontal diffusivity

Parameters

Table 3. Parameters for the COLD profiles

Parameter	Value	Description
T_0	$-1.9°C$	The surface temperature
T_{bot}	$-1.9°C$	The temperature at the ocean floor
S_0	33.8 psu	The surface salinity
S_{bot}	34.4 psu	The salinity at the ocean floor

Table 4. Parameters for the WARM profiles

Parameter	Value	Description
T_0	$-1.9°C$	The surface temperature
T_{bot}	$2.0°C$	The temperature at the ocean floor
S_0	33.8 psu	The surface salinity
S_{bot}	34.7 psu	The salinity at the ocean floor